PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : A47L 9/28, H01M 2/10

A1

(11) International Publication Number: WO 00/36969

(43) International Publication Date: 29 June 2000 (29.06.00)

(21) International Application Number: PCT/GB99/04079

(22) International Filing Date: 6 December 1999 (06.12.99)

(30) Priority Data:
9827780.9 18 December 1998 (18.12.98) GB

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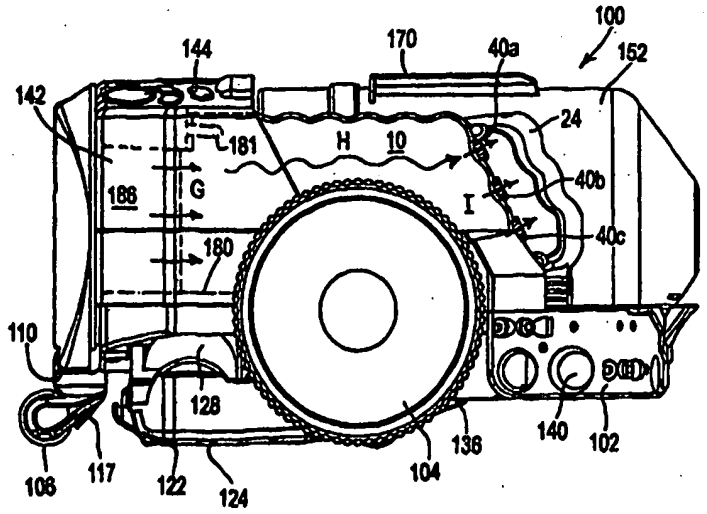
(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: VACUUM CLEANING APPLIANCE WITH A BATTERY PACK



(57) Abstract

A vacuum cleaning appliance (100) comprises a dirt and dust separating apparatus (152) and a fan (200) and fan motor (220) for generating an airflow from a dirty air inlet (124), through the dirt and dust separating apparatus (152) to a cleaned air outlet (40a, b, c). The appliance (100) is powered by a battery pack (10) which is located downstream of the fan along the airflow path through the appliance (100). The battery pack (10) has a housing (12) containing a plurality of cells (18), an inlet port (38) for receiving a stream of cooling fluid from the airflow path and at least one outlet port (40) for emitting the stream of cooling fluid, and a cooling fluid path between the inlet port or ports (38) and the outlet port or ports (40) for carrying cooling fluid therebetween. The cooling during discharging of the cells (18) allows the cells (18) to operate at or near their optimum temperature in order to maximise efficiency and energy consumption. It also provides a silencing function.

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Vacuum Cleaning Appliance with a Battery Pack

The invention relates to a vacuum cleaning appliance powered by a battery pack. The vacuum cleaning appliance can be an autonomous or robotic vacuum cleaner.

Battery packs are commonly used as power sources in electrical devices and appliances where portability and/or independent operation is required. Battery technology is improving at a considerable rate and increasing demands are being placed on battery-operated devices and appliances in terms of the power which they are required to consume and the time for which they are required to operate. This puts increasing demands on the battery packs used to power the electrical devices and appliances in terms of the power they are required to store and the rate at which they are required to discharge and be recharged.

One problem which can occur in situations of this sort relates to the heat which is generated during both charging and discharging of the cells of the battery pack. If a particular cell becomes too hot, it will not operate under optimum conditions and maximum efficiency of the battery pack (and therefore the apparatus or device) will not be achieved.

JP 7-250788 (Matsushita) describes a vacuum cleaner powered by a battery pack. The battery pack is located upstream of the fan of the vacuum cleaner, and in use air is drawn through the battery pack to cool the pack.

The present invention seeks to provide a battery powered vacuum cleaning appliance that minimises or overcomes problems with the prior art. It is an object of the invention to provide a vacuum cleaning appliance in combination with a battery pack which discharges under optimum conditions for a higher proportion of its operating time than known combinations. It is another object of the invention to provide a method of cooling a battery pack forming part of an electrical appliance in an efficient and effective way.

Accordingly, an aspect of the invention provides a vacuum cleaning appliance comprising a body having a dirty air inlet, a cleaned air outlet, a dirt and dust separating apparatus and an airflow path between the inlet and outlet via the dirt and dust separating apparatus, a fan for generating an airflow along the path and a battery pack for powering the appliance, the battery pack being located downstream of the fan along the airflow path, the battery pack having a housing containing a plurality of cells, the housing including at least one inlet port for receiving a stream of cooling fluid from the airflow path and at least one outlet port for emitting the stream of cooling fluid, and a cooling fluid path between the inlet port or ports and the outlet port or ports for carrying cooling fluid therebetween.

The provision of inlet and outlet ports to receive and emit a stream of cooling fluid allows a fluid stream to pass through the interior of the housing and around and across the cells themselves in order to achieve a cooling effect. The ability of the cells to charge and discharge at comparatively low temperatures increases the efficiency at which they operate and fewer losses therefore occur. This has the advantage of increasing the amount of energy which is made available to the appliance which is powered by the battery pack and thus raising the energy efficiency of that appliance. Locating the battery pack downstream of the fan has some important advantages. The air that passes through the battery pack is air that has been warmed above atmospheric temperature. The warming is partly due to the air having been made to do work, and partly due to cooling the fan motor. Passing warmed air through the battery pack still has a cooling effect on the pack, since the pack operates at a higher temperature than the warmed air, but the use of warmed air has the advantage that it causes a lower temperature gradient across the pack, between the inlet of the pack where the air enters the pack, and the outlet where the air exits the pack. This results in cells of the pack discharging at a more uniform rate with a lower risk of failure. Furthermore the battery packs have a beneficial silencing effect on exhaust air, helping to reduce the noise level of exhausted air. The mass of the battery pack and the meandering path that the air is forced to take through the pack helps to reduce the noise level. Thus, the appliance can

operate at lower noise levels using an existing component - the battery pack – without the need for an additional silencer, a heavy device which is undesirable in a cordless machine.

A further advantage of locating the battery pack downstream of the fan is that the requirements for sealing the airflow path to the battery pack are lessened. This is because the air passing through the battery pack is exhaust air.

Preferably, the cells of the battery pack are arranged directly in the cooling fluid path so as to maximise the cooling effect of the cooling fluid. More preferably, the inlet port or ports is or are arranged at a first end of the battery pack and the outlet port or ports is or are arranged at a second end of the battery pack remote from the first end.and the outlet port or ports is or are spread across an area of the second end which is substantially equal to the area occupied by the cells adjacent the second end of the housing. This arrangement ensures that the cooling fluid spreads across the whole of the housing and traverses all of the cells, at least in the area of the outlet or outlets.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, wherein:

Figure 1 is a perspective view of a battery pack according to the invention;

Figures 2a and 2b are plan views of first and second parts of the battery pack of Figure 1;

Figure 3 is a perspective view of a vacuum cleaner carrying and powered by battery packs as shown in Figures 1 and 2;

Figures 4, 5 and 6 are plan, rear and side views respectively of the vacuum cleaner of Figure 3;

Figure 7 is a sectional view along line V-V of Figure 5;

Figure 8 is a schematic diagram of the airflow through the vacuum cleaner;

Figure 9 is a sectional detail showing the connection between one of the battery packs of Figure 1 and the vacuum cleaner of Figures 3 to 6; and

Figure 10 is a schematic side view of a battery charger in combination with the battery pack of Figure 1.

A battery pack 10 for use in the invention is illustrated in Figures 1 and 2. The battery pack 10 has a housing 12 which is made up of two half shells 14a, 14b made from a plastics material such as Nylon or ABS. The half shells 14a, 14b are essentially symmetrical and together define an enclosure 16 in which a plurality of cells 18 are located. The cells 18 are connected in two groups 18a, 18b as illustrated in Figure 2a, with a flexible connection 19 being provided between cells 18b' and 18b". The cells 18 are spaced apart and maintained in their fixed positions by spacer walls 20 which are formed of insulating material and specifically adapted to conform to and follow the contours of the side walls of the cells 18 in order to hold them securely in position. The spacer walls 20 are preferably moulded integrally with the half shells 18a, 18b and are therefore formed from the same material as the half shells 18a, 18b. In the illustrated embodiment, thirty cells 18 are provided in the housing in two groups of fifteen cells. The cells are preferably nickel-cadmium sub-C cells with a rating of 2.0 ampere-hours or greater, or nickel metal hydride (Ni MH) cells having a rating of 3.0 ampere-hours or greater. The half shells 18a, 18b are joined together by way of screws or non-releasable fasteners 22a, 22b located in the half shells 18a, 18b.

The housing 12 has a front end 12a which carries a handle 24 by means of which the battery pack 10 can be carried. The handle 24 is profiled so as to conform to the shape of a user's hand for comfort and grip. The interior of the handle 24, ie on the side of the handle 24 facing the body of the housing 12, comprises a lever portion 26 (see Figure 2a) which is also profiled to conform to the contours of a user's hand. The lever portion 26 is moulded from a plastics material and is pivotably connected to the housing 12 at the base of the handle 24 by way of a pivot connection 28. The lever portion 26 is biased into the position shown in Figure 2a by a spring 30. The lever portion 30 also carries a downwardly projecting tooth 32 located on an arm of the lever portion which projects generally horizontally away from the pivot connection 28. The tooth 32 projects downwardly through an aperture 34 in the lower surface of the housing as

illustrated in Figure 2b. The fixed portion 24a of the handle 24 is recessed so that the lever portion 26 can pivot about the pivot connection 28 with respect to the fixed portion 24a and against the biasing action of the spring 30. This action results in the tooth 32 being lifted sufficiently for that the tooth no longer projects through the aperture 34.

The housing 12 incorporates at least one electrical connection 36 which is in electrical communication with the cells 18 in whichever configuration is appropriate for the appliance to be powered by the battery pack 10. The electrical connection 36 is located at the end of the housing 12 remote from the handle 24 and is preferably surrounded by a collar or is otherwise recessed for safety reasons.

The housing 12 also has an inlet port 38 which is capable of receiving cooling fluid and passing it directly to the enclosure 16. The inlet port 38 therefore essentially comprises an opening leading directly from the exterior of the housing 12 to the interior thereof. the inlet port is located, like the electrical connector, at the end of the housing 12 remote from the handle 24. The opening is covered, at least in part, by protective fins 38a which are present partly to prevent any foreign bodies from entering the housing, partly to strengthen the housing, and partly to diffuse the incoming cooling fluid. At least one outlet 40 is provided at the end of the housing 12 opposite the end at which the inlet port 38 is located. In the illustrated embodiment, there are four outlet ports provided 40a, 40b, 40c and 40d, each of which are covered, at least in part, by protective fins 40e. The outlet ports 40 are spaced over the end 12a of the housing 12 so that there is an outlet port 40a, 40d adjacent the most remotely spaced cells 18 at the end of the enclosure 16 closest to the handle 24.

A temperature sensor 42 is located in the enclosure adjacent one of the outlet ports 40. The sensor 42 can be mounted in the enclosure between two cells 18 as shown in bold lines in Figure 2b, or else it can be mounted directly on one of the cells 18 as shown in dotted lines in the same Figure. The sensor 42 is connected to an indicator located at a convenient position on the housing 12 to give an indication to the user if the

temperature inside the housing 12 becomes dangerously high. Alternatively, the sensor can be connected directly to electrical appliance which is powered by the battery pack 10 via the connection 36 to operate a switch which will deactivate the appliance if the battery pack becomes too hot.

Located on the lower surface of the housing 12 at the end 12a thereof adjacent the handle 24, are two opposing lugs 44 projecting outwardly from the housing 12. The lugs extend in a horizontal plane as can be seen from Figure 7, to which further reference will be made below. The purpose of the lugs 44 will be explained later with reference to Figure 9.

The battery pack 10 described above can be used to power a robotic vacuum cleaner as illustrated in Figures 3 to 7. The term "robotic" is here used to mean that the vacuum cleaner is capable of operating so that it navigates its own way around a room to be cleaner without human intervention and without bumping into, or becoming lodged against, obstacles located around the room. An overview of such a machine is given below.

The vacuum cleaner 100 shown in the said drawings has a supporting chassis 102 which is generally circular in shape and is supported on two driven wheels 104 and a castor wheel 106. The chassis 102 is preferably manufactured from high-strength moulded plastics material, such as ABS, but can equally be made from metal such as aluminium or steel. The chassis 102 provides support for the components of the cleaner 100 which will be described below. The driven wheels 104 are arranged at either end of a diameter of the chassis 102, the diameter lying perpendicular to the longitudinal axis of the cleaner 100. Each driven wheel 104 is moulded from a high-strength plastics material and carries a comparatively soft, ridged band around its circumference to enhance the grip of the wheel 104 when the cleaner 100 is traversing a smooth floor. The soft, ridged band also enhances the ability of the wheels 104 to mount and climb over small obstacles. The driven wheels 104 are mounted independently of one another via support bearings (not shown) and each driven wheel 104 is connected directly to a motor which

is capable of driving the respective wheel 104 in either a forward direction or a reverse direction. By driving both wheels 104 forward at the same speed, the cleaner 100 can be driven in a forward direction. By driving both wheels 104 in a reverse direction at the same speed, the cleaner 100 can be driven in a backward direction. By driving the wheels 104 in opposite directions, the cleaner 100 can be made to rotate about its own central axis so as to effect a turning manoeuvre. The aforementioned method of driving a vehicle is well known and will not therefore be described any further here.

The castor wheel 106 is significantly smaller in diameter than the driven wheels 104 as can be seen from, for example, Figure 6. The castor wheel 106 is not driven and merely serves to support the chassis 102 at the rear of the cleaner 100. The location of the castor wheel 106 at the trailing edge of the chassis 102, and the fact that the castor wheel 106 is swivellingly mounted on the chassis by means of a swivel joint 110, allows the castor wheel 106 to trail behind the cleaner 100 in a manner which does not hinder the manoeuvrability of the cleaner 100 whilst it is being driven by way of the driven wheels 104. The swivel joint 110 is most clearly shown in Figure 6. This type of arrangement is well known. The castor wheel 106 can be made from a moulded plastics material or can be formed from another synthetic material such as Nylon.

Mounted on the underside of the chassis 102 is a cleaner head 122 which includes a suction opening 124 facing the surface on which the cleaner 100 is supported. The suction opening 124 is essentially rectangular and extends across the majority of the width of the cleaner head 122. A brush bar (not shown) is rotatably mounted in the suction opening 124 and a motor 128 is mounted on the cleaner head 122 for driving the brush bar by way of a drive belt (not shown) extending between a shaft of the motor 128 and the brush bar. The cleaner head 122 is mounted on the chassis 102 in such a way that the cleaner head 122 is able to float on the surface to be cleaned. This is achieved in this embodiment in that the cleaner head 122 is pivotally connected to an arm (not shown) which in turn is pivotally connected to the underside of the chassis 102. The double articulation of the connection between the cleaner head 122 and the chassis 102 allows the cleaner head to move freely in a vertical direction with respect to the chassis

102. This enables the cleaner head to climb over small obstacles such as books, magazines, rug edges, etc. Obstacles of up to approximately 25mm in height can be traversed in this way. A flexible or telescopic conduit is located between a rear portion of the cleaner head 122 and an inlet port located in the chassis 102.

In order to assist the cleaner head 122 to move vertically upwards when an obstacle is encountered, forwardly projecting ramps 136 are provided at the front edge of the cleaner head 122. In the event that an obstacle is encountered, the obstacle will initially abut against the ramps 136 and the inclination of the ramps will then lift the cleaner head 122 over the obstacle in question so as to avoid the cleaner 100 from becoming lodged against the obstacle. The cleaner head 122 is shown in a lowered position in Figure 6. The castor wheel 106 also includes a ramped portion 117 which provides additional assistance when the cleaner 100 encounters an obstacle and is required to climb over it. In this way, the castor wheel 106 will not become lodged against the obstacle after the cleaner head 122 has climbed over it.

As can be seen from Figures 3 and 4, the cleaner head 122 is asymmetrically mounted on the chassis 102 so that one side of the cleaner head 122 protrudes beyond the general circumference of the chassis 102. This allows the cleaner 100 to clean up to the edge of a room on the side of the cleaner 100 on which the cleaner head 122 protrudes.

The chassis 102 carries a plurality of sensors 140 which are designed and arranged to detect obstacles in the path of the cleaner 100 and its proximity to, for example, a wall or other boundary such as a piece of furniture. The sensors 140 comprise several ultra-sonic sensors and several infra-red sensors. The array illustrated in Figures 3 and 5 is not intended to be limitative and the arrangement of the sensors does not form part of the present invention. Suffice it to say that the vacuum cleaner 100 carries sufficient sensors and detectors 140 to enable the cleaner 100 to guide itself or to be guided around a predefined area so that the said area can be cleaned. Control software, comprising navigation controls and steering devices, is housed within a housing 142 located beneath a control panel 144 or elsewhere within the cleaner 100.

The vacuum cleaner 100 also includes a motor and fan unit supported on the chassis 102 for drawing dirty air into the vacuum cleaner 100 via the suction opening 124 in the cleaner head 122. The chassis 102 also carries a cyclonic separator 152 for separating dirt and dust from the air drawn into the cleaner 100. The inlet port which communicates with the rear portion of the cleaner head 122 via the conduit mentioned above forms the inlet to the cyclonic separator 152. The cyclonic separator, which preferably comprises two cyclones in series, need not be described any further here, being known technology and described adequately elsewhere.

The cyclonic separator 152 is releasable from the chassis 102 in order to allow emptying of the cyclonic separator 152. A hooked catch (not shown) is provided by means of which the cyclonic separator 152 is held in position when the cleaner 100 is in use. When the hooked catch is released (by manual pressing of a button 134 located in the control panel 44), the cyclonic separator 152 can be lifted away from the chassis 102 by means of gripper portions 170. The cyclonic separator 152 can then be emptied.

Two battery packs 10 as described above are located on the chassis 102 on either side of the cyclonic separator 152. The battery packs 10 are identical and are spaced from the central axis of the vacuum cleaner 100 by a significant distance, say between 50 and 150 mm. In the embodiment illustrated, the battery packs are spaced from the central axis of the vacuum cleaner by a distance of about 87 mm. The provision of two separate battery packs 10 allows the weight thereof to be evenly distributed without requiring the battery pack to be located directly over the centre of the cleaner 100. This gives much greater flexibility of design and allows the dirt and dust collecting means of the cleaner 100 (in this case the cyclonic separator 152) to occupy the most central position. This can be beneficial for the user.

The battery packs 10 are held in position on the chassis 102 so that the battery packs are not permitted to move during normal use of the vacuum cleaner 100. The end of each battery pack 10 remote from the handle 24 is received in a recess 180 formed in the

structure of the vacuum cleaner 10 (see Figure 6). The recess 180 is formed in the moulding 142 which forms a housing for the motor and fan unit, which housing 142 is fixedly attached to the chassis 102. The end of the battery pack housing 12 remote from the handle 24 is thus held securely on the chassis 102. Located in the recess 180 is a connector point 181 for forming an electrical connection with the battery pack 10. The electrical connector point 181 is positioned so that it is aligned with the electrical connection 36 on the battery pack 10 and projects into the recess 180 so that the connector point 181 and the connection 36 are automatically brought into electrical contact when the battery pack 10 is inserted fully into the recess 180. Also formed in the housing 142 of the motor and fan unit is a duct 186 which carries air exiting the fan from the fan to an opening in the housing 142 which is located directly adjacent the inlet port 38 of the battery pack 10 when it is mounted on the chassis 102.

The chassis 102 also includes a pair of undercut grooves or channels 182 located in the portion of the chassis 102 adjacent the handle 24 of the battery pack 10. The grooves or channels 182 are open at the ends thereof facing the handles 24 of the battery packs 10 and are spaced apart by a distance which is slightly less than the spacing of the lugs 44. An aperture 184 corresponding to the cross-sectional area of the tooth 34 is positioned in the chassis 102 between the two grooves or channels 182. The location of the aperture 184 is such that it is aligned with the aperture 34 when the battery pack 10 is fully inserted in the recess 180. The arrangement is illustrated in Figure 9.

In the Figure, a section through the battery pack 10 is illustrated showing the lower surface of the housing 12 with the aperture 34 therein. The tooth 32 is also shown in its normal position of projecting through the aperture 34. In this position, the tooth 34 also projects through the aperture 184 in the chassis 102 and thereby prevents relative movement between the chassis 102 and the battery pack 10 in the direction of the channels or grooves 182. The lugs 44 extend outwardly from the lower surface of the housing 12 and are received in the grooves or channels 182 so that movement in other directions is prevented and the opposite end of the battery pack 10 is held securely in

the recess 180. The battery pack 10 is thereby held securely in position on the chassis 102.

In order to release the battery pack 10 from the chassis 102, for example when recharging is required, the handle 24 of the battery pack is grasped by the user. The grasping motion squeezes the lever portion 26 of the handle towards the fixed portion about the pivot connection 28 so that the tooth 34 is raised and is released from the apertures 184, 34. The battery pack 10 is then able to move in a sliding manner so that the lugs 44 slide along the grooves or channels 182 until they are released therefrom. The battery pack 10 can then be lifted so that the end opposite the handle 24 emerges from the recess 180 and the battery pack 10 can be removed. The battery pack 10 is returned to the chassis 102 in an identical manner, but in reverse: the end of the battery pack 10 is slid into the recess 180 in a direction along the grooves or channels 182. The sliding motion causes the lugs 44 to be received into the channels 182 and, as the battery pack 10 becomes fully received into the recess 180, the tooth 34 drops through the aperture 184 under the action of the spring 30 to hold the battery pack 10 in position and the electrical connection is automatically made between the cleaner 100 and the battery pack 10. The inlet port 38 is also automatically aligned with the opening of the duct 186. The connector point 181 is connected, within the cleaner 10, to the motor and fan unit, to the brush bar motor 28, to the motors for the driven wheels 104, and to the sensors 140 and control software so that all powered components of the cleaner 10 are able to take their power from the battery pack 10.

The vacuum cleaner 100 described above operates in the following manner. In order for the cleaner 100 to traverse the area to be cleaned, the wheels 104 are driven by the motors which, in turn, are powered by the batteries 10. The direction of movement of the cleaner 100 is determined by the control software which communicates with the sensors 140 which are designed to detect any obstacles in the path of the cleaner 100 so as to navigate the cleaner 100 around the area to be cleaned. Methodologies and control systems for navigating a robotic vacuum cleaner around a room or other area are well documented elsewhere and do not form part of the inventive concept of this invention.

Any of the known methodologies or systems could be implemented here to provide a suitable navigation system. The battery packs 10 also power the motor and fan unit which draws air into the cleaner 100 via the cleaner head 122 and passes it to the cyclonic separator 152 where the dirt and dust is separated from the airflow. The battery packs 10 are also used to power the motor 28 which drives the brush bar which, in turn assists with pick-up, particularly on carpets.

Figures 6 and 7 show the airflow path through the vacuum cleaner 100. Figure 8 schematically shows the airflow path. Air drawn through dirty air inlet 124 of cleaner head 122 flows through cyclonic separator 152 where dirt and dust is separated from the airflow. Air then follows the path shown by the arrows located A – I in Figures 6 and 7. Beginning with Figure 7, air exits the cyclonic separator 152 through vortex finder 240 (arrow A). It is forced radially outwards by fan 200 (B) and passes around the ouside of the fan motor unit 210 (C) where it is further heated by cooling the fan motor unit 210. The air then passes through a post-motor filter 220 (D,E) which filters any remaining particulates from the air. The air then passes (F) through an aperture 230 in the housing of the post-motor filter. As seen in Figure 6, the air is then conducted along the duct 186 to the opening adjacent the inlet port 38 of the battery pack 10. The air is then forced to enter the battery pack housing 12 via the inlet port 38 (G) and pass into the enclosure 16. The air passes around and across (H) the cells 18 in order to achieve a cooling effect before exiting the battery pack (I) via the outlet ports 40. The spacing of the outlet ports 40a, 40b, 40c, 40d across the end 12a of the housing 12 ensures that the cooling air is spread throughout the enclosure 16 and is discouraged from following a restricted path which might result in some cells 18 being cooled less effectively than others. The air is expelled to the atmosphere from the outlet ports 40. Passing the exiting air through the battery packs 10 also attenuates the noise of the exiting air and thus reduces the volume at which the cleaner 100 operates.

The inlet and outlet ports 38, 40 can also be put to good effect when the battery pack 10 is being recharged. Apparatus for recharging a battery pack 10 is illustrated in Figure 9. The apparatus comprises a recharger 200 having an appropriate mains supply

connection 202 and a recess 204 for receiving the battery pack 10. Electrical connectors are provided in the recess 204 for supplying power to the battery pack for recharging purposes. Also provided in the recharger 200 is a fan 206, which is mains operated, for drawing air into the recharger 200 from the atmosphere via a first duct 208. A second duct 210 carries the air drawn into the recharger by the fan 206 from the fan 206 to the recess 204. The second duct 210 opens into the recess 204 immediately adjacent the inlet port 38 of the battery pack 10 when the battery pack 10 is located in the recess 204. Thus, when the battery pack 10 is inserted into the recess 204 for charging purposes, the fan draws air into the recharger 200 and passes it through the second duct 210 and into the housing 12 of the battery pack 10 in order to cool the cells during the recharging process. The cooling air is then expelled to the atmosphere via the outlet ports 40, in the same way as it is expelled during operation of the vacuum cleaner 100.

It will be appreciated that the recharger 200 can have a number of features which will assist the recharger 200 to operate with minimum user intervention. Features such as switches, located in the recess 204, which will automatically commence the recharging operation and/or bring the fan 206 into operation can be incorporated if desired.

The invention is not intended to be limited to the precise details of the embodiment illustrated above.

Claims:

1. A vacuum cleaning appliance comprising a body having a dirty air inlet, a cleaned air outlet, a dirt and dust separating apparatus and an airflow path between the inlet and outlet via the dirt and dust separating apparatus, a fan for generating an airflow along the path and a battery pack for powering the appliance, the battery pack being located downstream of the fan along the airflow path, the battery pack having a housing containing a plurality of cells, the housing including at least one inlet port for receiving a stream of cooling fluid from the airflow path and at least one outlet port for emitting the stream of cooling fluid, and a cooling fluid path between the inlet port or ports and the outlet port or ports for carrying cooling fluid therebetween.

2. An appliance as claimed in Claim 1, wherein the cells are arranged directly in the cooling fluid path.

3. An appliance as claimed in Claim 1 or 2, wherein the inlet port or ports is or are arranged at a first end of the battery pack and the outlet port or ports is or are arranged at a second end of the battery pack remote from the first end.

4. An appliance as claimed in Claim 3, wherein the outlet port or ports is or are spread across an area of the second end which is substantially equal to the area occupied by the cells adjacent the second end of the housing.

5. An appliance as claimed in any one of the preceding claims, wherein the outlet part of the battery pack exhausts the cooling fluid directly to the atmosphere.

6. An appliance as claimed in any one of the preceding claims wherein the inlet of the battery pack receives substantially all of the airflow along the airflow path.

7. An appliance as claimed in any one of Claims 1 to 5 having a plurality of the battery packs and wherein the inlets of the battery packs receive substantially all of the airflow along the airflow path.

8. An appliance as claimed in any one of the preceding claims, wherein a temperature sensor is arranged inside the housing.

9. An appliance as claimed in Claim 8, wherein the temperature sensor is mounted within the housing adjacent the or an outlet port.

10. An appliance as claimed in Claim 9, wherein the temperature sensor is mounted on one of the cells.

11. An appliance as claimed in any one of the preceding claims, wherein the battery pack housing comprises means for attaching the battery pack to the appliance.

12. An appliance as claimed in Claim 11, wherein the battery pack housing further comprises means for releasing the battery pack from the appliance.

13. An appliance as claimed in any one of the preceding claims, wherein the battery pack housing comprises electrical connections for forming an electrical connection between the battery pack and the appliance.

14. An appliance as claimed in any one of the preceding claims, wherein the battery pack is rechargeable.

15. An electrical appliance and battery pack combination as claimed in any one of the preceding claims, wherein the dirt and dust separating apparatus comprises a cyclonic separator.

16. An electrical appliance and battery pack combination as claimed in Claim 15, wherein the cyclonic separator comprises two cyclones arranged in series.

17. An appliance as claimed in any one of the preceding claims, wherein the vacuum cleaner is autonomous.

18. A method of cooling a battery pack forming a power supply for a vacuum cleaning appliance, the method comprising using a fan of the appliance to generate an airflow along an airflow path through the appliance, from a dirty air inlet, through a dirt and dust separating apparatus and through a cooling fluid path of the battery pack to a cleaned air outlet of the appliance, the battery pack being located downstream of the fan along the airflow path.

FIG.1.

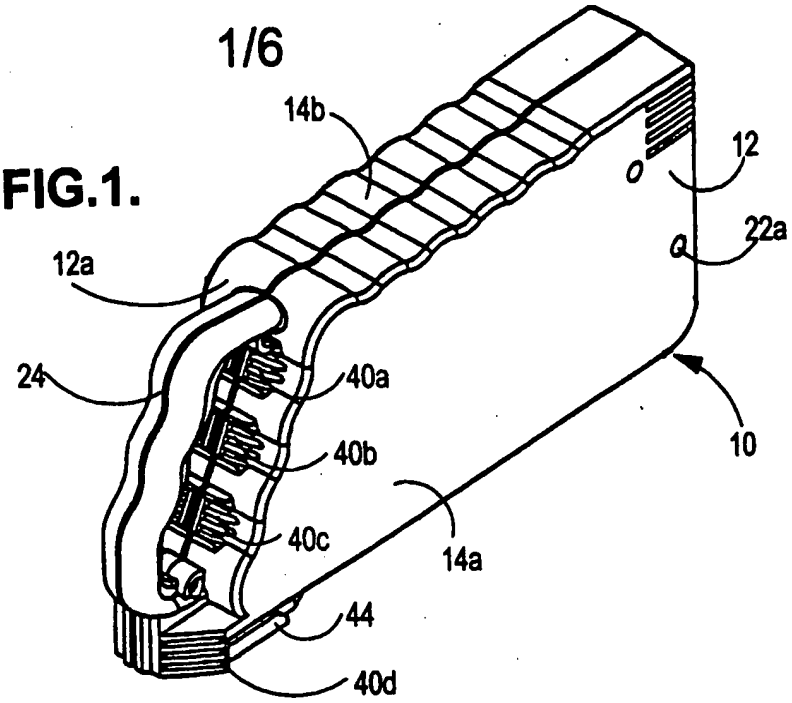
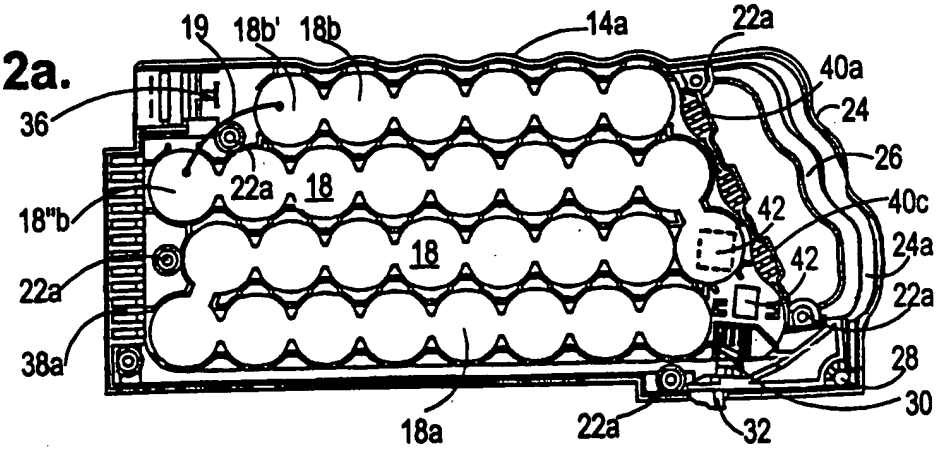


FIG.2a.



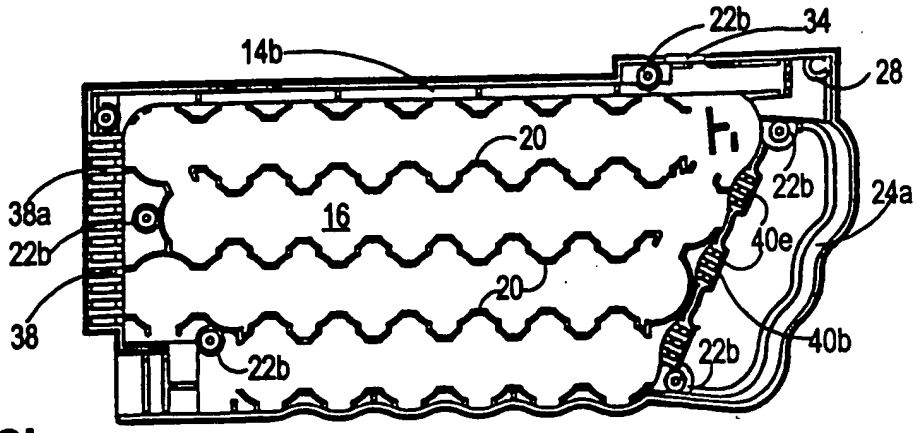
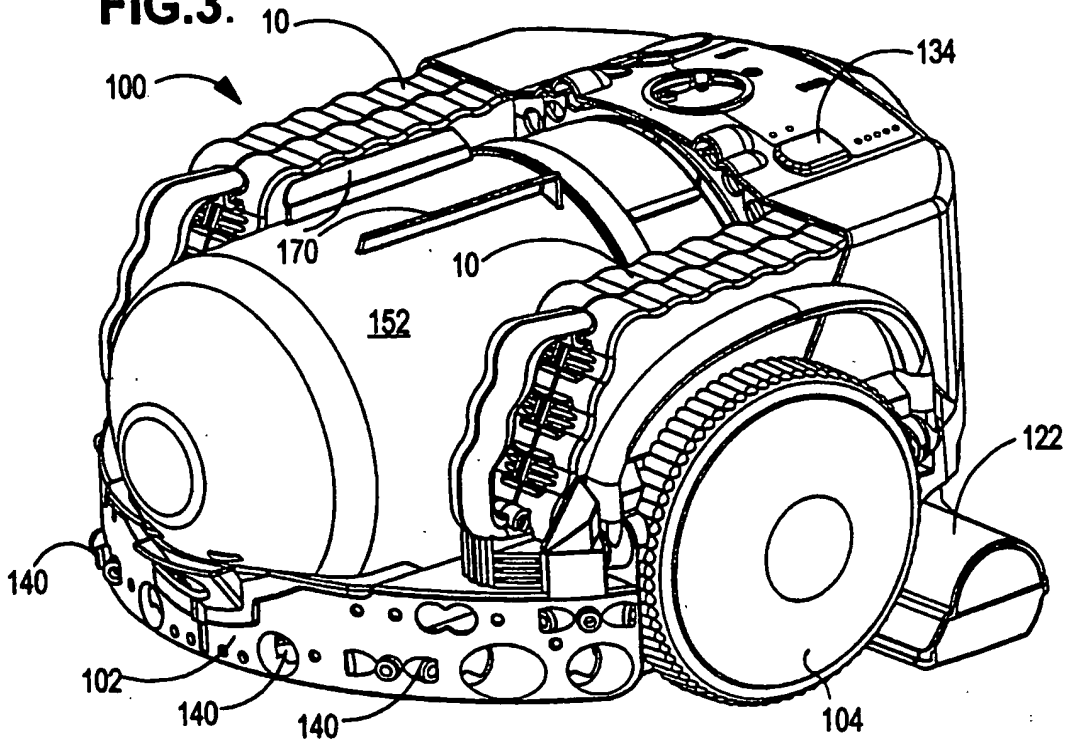


FIG.2b.

FIG.3.


10
100
134
170
10
152
122
140
102
140
140
104

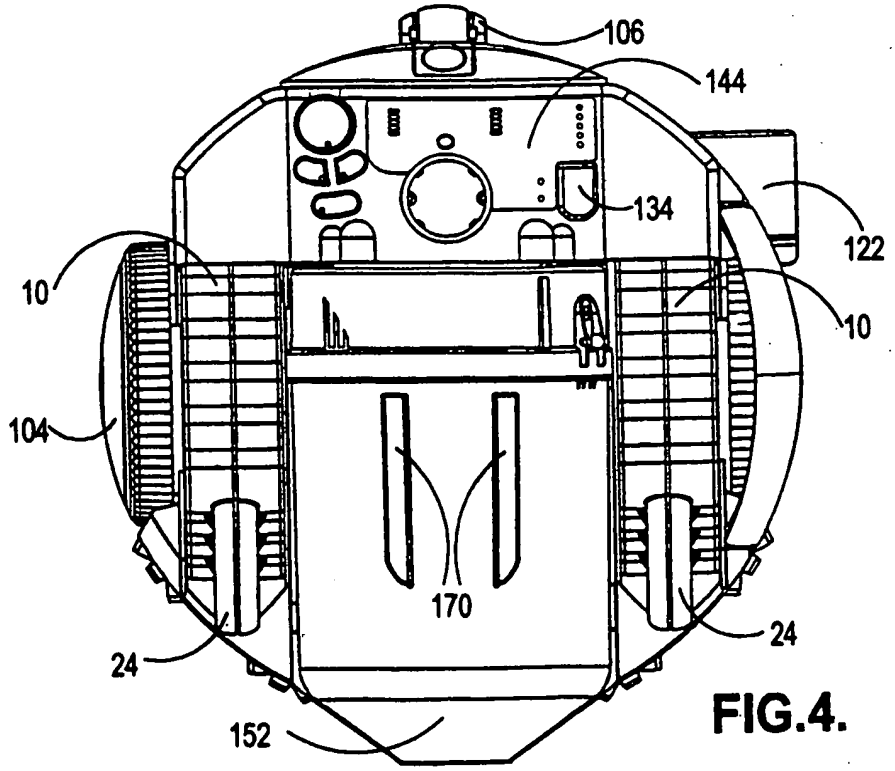

106
144
134
122
10
10
104
170
24
24
152

FIG.4.

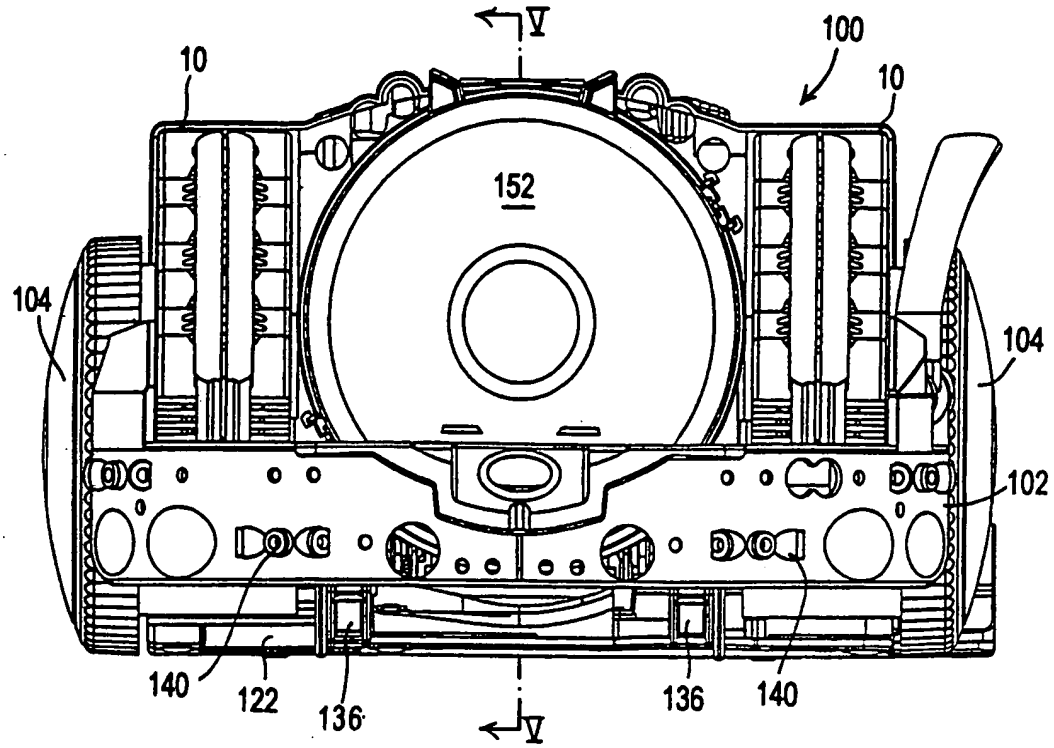

V
100
10
10
152
104
104
102
140
122
136
136
140
V

FIG.5.

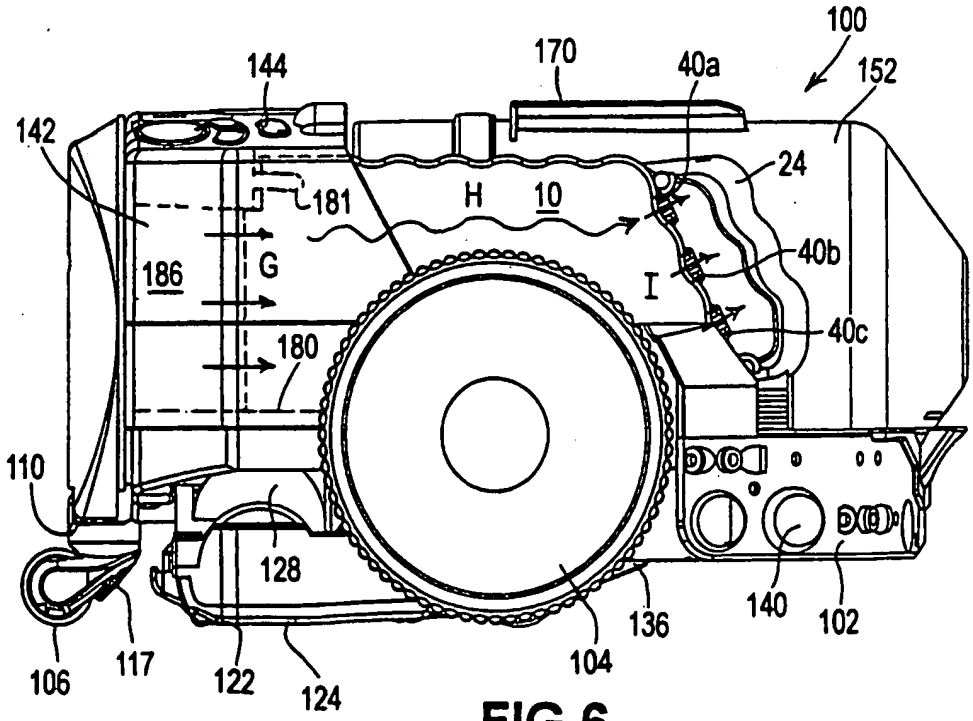

100
144
170
40a
152
142
24
181
H
10
40b
186
G
I
40c
180
110
128
140
102
136
106
117
122
124
104

FIG.6.

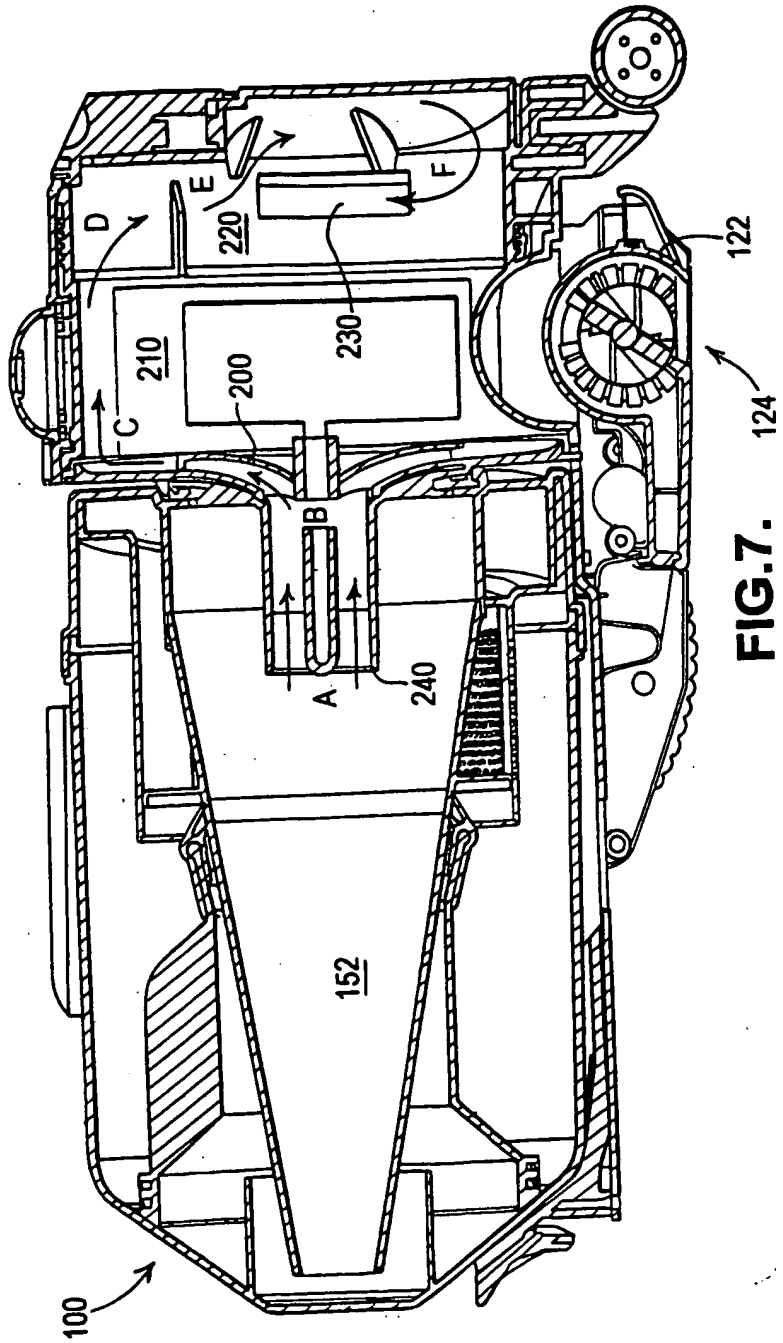


FIG.7.

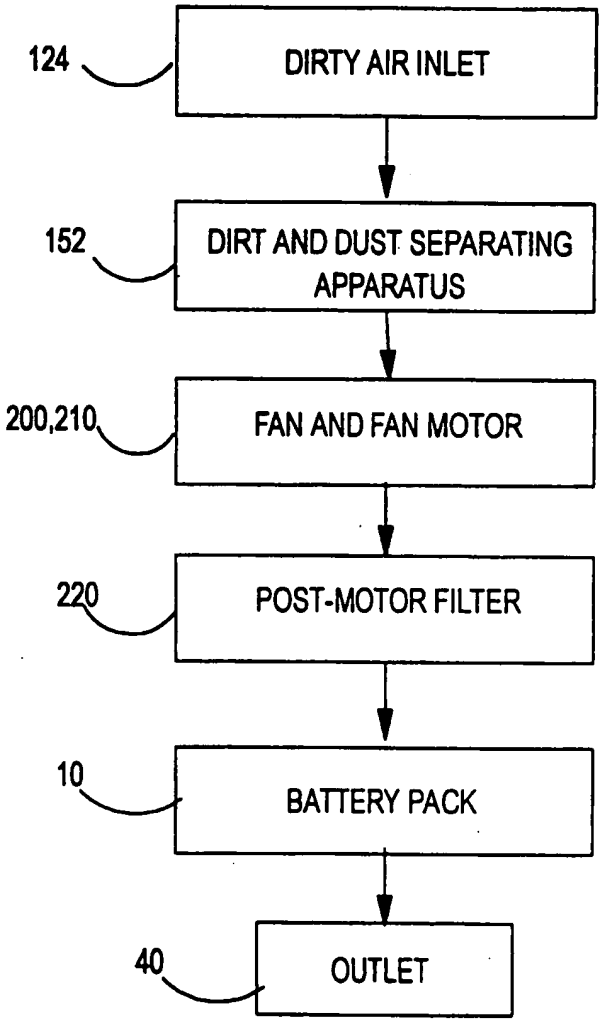

124
DIRTY AIR INLET
152
DIRT AND DUST SEPARATING APPARATUS
200,210
FAN AND FAN MOTOR
220
POST-MOTOR FILTER
10
BATTERY PACK
40
OUTLET

FIG.8.

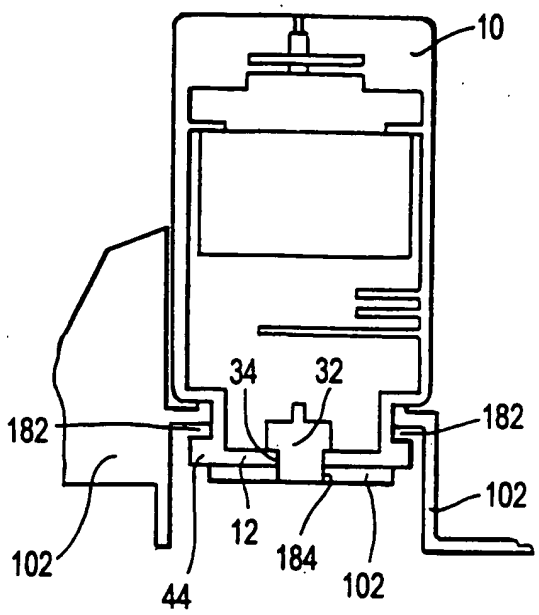


FIG 9

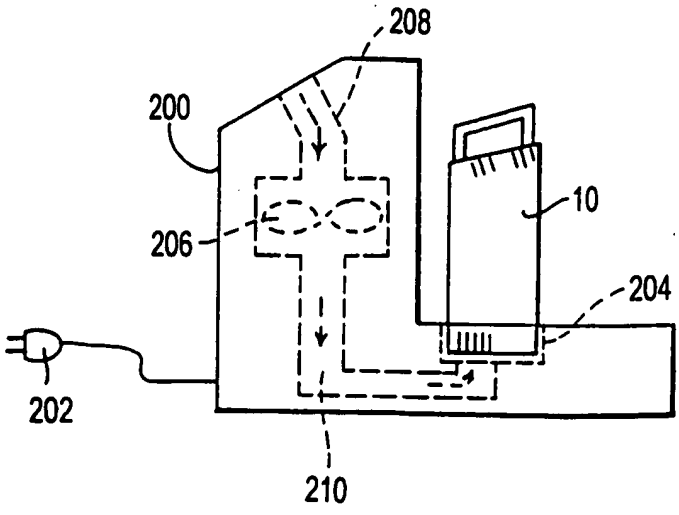


FIG 10

INTERNATIONAL SEARCH REPORT

Inte Ional Application No
PCT/GB 99/04079

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A47L9/28 H01M2/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A47L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 1996, no. 2, 20 February 1996 (1996-02-20) -& JP 07 250788 A (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.), 3 October 1995 (1995-10-03) cited in the application abstract	1-7, 11-14,18
A	US 5 596 236 A (J.-B. LEE ET AL.) 21 January 1997 (1997-01-21)	
A	EP 0 635 236 A (A. M. BOESI) 25 January 1995 (1995-01-25)	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 March 2000	22/03/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Bourseau, A-M

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inte ional Application No
PCT/GB 99/04079

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